

Appl. No. : **10/074,534**
Filed : **February 11, 2002**

REMARKS

Applicant has received the Office Action of March 25, 2004 ("Office Action"). Claims 1-33 are currently pending in this application.

Amendment to the Claims

The Amendment to the Claims set forth above cancels Claims 16-19, which had been previously withdrawn as being directed to a non-elected invention.

Applicant reserves the right to file divisional and/or continuation applications containing claims directed to all or part of the subject matter described in the instant application, as well as the subject matter of any claims amended or canceled at any time during the prosecution of this application, and thus unclaimed subject matter is not dedicated to the public

Information Disclosure Statements (IDS's)

The Office Action received by Applicant was accompanied by initialed copies of the PTO-1449 forms submitted by Applicant with the IDS's filed on October 16, 2003 and September 26, 2003. Applicant understands that the Office has received and considered the references submitted by Applicant with the IDS filed on August 19, 2003 (a courtesy copy of that IDS was sent to the Office on December 3, 2003). However, Applicant has not received initialed copies of the PTO-1449 forms submitted with the IDS's filed on August 19, 2003, May 6, 2003 and November 25, 2002, and respectfully requests that such copies be provided with the next Office Action. Copies of the IDS's filed on August 19, 2003, May 6, 2003 and November 25, 2002 are enclosed herewith for the convenience of the Office.

Claim Rejections - 35 U.S.C. § 103(a)

Claims 1-15 and 20-33 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Rolfson (U.S. Patent No. 5,786,027) in view of U'Ren (U.S. Patent No. 6,365,479). Applicant respectfully traverses this rejection for the reasons discussed below.

Scope and Content of the Prior Art

In assessing obviousness, the Office is required to properly determine the scope and content of the prior art. *See M.P.E.P. § 2141.01.* The Office states that "Rolfson discloses a

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process for depositing a non-single crystalline Si-Ge-containing material on to a surface. . . .” Office Action at 3; *see also* Paper No. 9 at 4, 6. Applicant respectfully disagrees because Rolfson discloses a process for depositing a polysilicon material, not a SiGe-containing material. The portions of Rolfson cited by the Office (abstract lines 2-3 and col. 4, lines 11-14) do not teach or suggest the deposition of a SiGe-containing material. The Office also states that U’Ren “describes introducing a graded Si Ge-containing film onto the substrate by thermal CVD using a deposition gas comprising amounts of trisilane and a germanium precursor that are varied during deposition” Office Action at 5; *see also* Paper No. 9 at 6-7. Applicant respectfully disagrees because U’Ren does not disclose the use of trisilane.

The Office responds by stating that “Applicant’s arguments are based on the piece meal analysis of the references,” Office Action at 7, but fails to point out where Rolfson discloses the deposition of SiGe or where U’Ren discloses the use of trisilane. Applicant respectfully submits that the above-cited portions of the Office Action reflect a misunderstanding by the Office of the scope and content of Rolfson and U’Ren. Applicant notes that the statements made by the Office in the above-cited portions of the Office Action were also made in the prior Office Action, *see* Paper No. 9 at 4, 6-7, and thus it appears that the statements are not typographical errors by the Office. Applicant respectfully submits that the rejection of Claims 1-15 and 20-33 under 35 U.S.C. § 103(a) is due at least in part to an erroneous obviousness analysis based on a misunderstanding of Rolfson and U’Ren. Therefore, Applicant respectfully requests reconsideration and withdrawal of this rejection.

No Motivation to Combine Rolfson and U’Ren

There is no *prima facie* case of obviousness in the absence of a motivation to combine the cited references. *See* M.P.E.P. § 2143. The Office must consider the prior art as a whole when evaluating motivation: “A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention.” M.P.E.P. § 2121.03 (emphasis in original). The Office must consider “all teachings in the prior art . . . to the extent that they are in analogous arts.” M.P.E.P. § 2143.01.

The Office notes that Rolfson does not describe introducing a germanium precursor to the chamber to thereby deposit a non-single crystalline SiGe film, but indicates that U’Ren discloses the use of a germanium precursor and provides motivation to modify Rolfson to use the

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germanium precursor to deposit a non-single crystalline SiGe film. Office Action at 3-4. Thus, with respect to Claim 1, the Office states that:

[I]t would have been obvious to one of ordinary skill in the art at the time of the invention to include U'Ren's step of introducing a germanium precursor to the chamber and depositing a non-single crystalline SiGe containing film onto the substrate in Rolfson's method to provide a process that achieves the desired pre-determined profile that can be controlled in order to produce a multi layer stack with the desired profile (eg. devices with better gain, speed and frequency response).

Office Action at 3-4. Likewise, with respect to Claim 20, the Office states that:

[I]t would have been obvious to one of ordinary skill in the art at the time of the invention to include U'Ren's step of introducing a graded SiGe film onto the substrate by thermal CVD using a deposition gas comprising amounts of trisilane and a germanium precursor that are varied during deposition in Rolfson's method to provide a process that achieves the desired pre-determined profile that can be controlled in order to produce a multi layer stack with the desired profile (eg. devices with better gain, speed and frequency response).

Office Action at 6. Applicants respectfully disagree because one skilled in the art at the time of the claimed invention would not have been motivated by the disclosure of U'Ren to modify Rolfson to meet the instant claims. Therefore, Applicant respectfully submits that the Office has not established a *prima facie* case of obviousness. *See* M.P.E.P. § 2143.

Applicant respectfully directs the attention of the Office to the enclosed Declaration of Dr. Michael A. Todd Under 37 C.F.R. § 1.132 ("Todd Declaration"). The Office is respectfully invited to refer to the text of the Todd Declaration for the details of the facts and technical reasoning supporting the conclusions summarized below.

Dr. Todd is skilled in the art of semiconductor fabrication and has carefully reviewed Rolfson and U'Ren. *See* Todd Declaration at ¶¶ 1-2. Considered as a whole, Rolfson teaches the undesirability of film surface roughness and grain boundaries that extend from the surface of the film to the underlying substrate. *See* Todd Declaration at ¶¶ 3-6. U'Ren discloses methods for depositing SiGe films for use in semiconductor devices. *See* Todd Declaration at ¶ 7. U'Ren purports to disclose a method for concurrently depositing a polycrystalline SiGe region and a single-crystal SiGe region. *See* Todd Declaration at ¶ 7. U'Ren discloses that such concurrent deposition is accomplished by using a deposition temperature and pressure at which deposition of polycrystalline SiGe occurs in a mass-controlled mode and deposition of single crystal SiGe

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occurs in a kinetically-controlled mode. *See* Todd Declaration at ¶ 7. Those skilled in the art were generally aware that the addition of germane to a silane-based CVD process increased the roughness and the depth of the grain boundaries in the resulting SiGe film. *See* Todd Declaration at ¶ 8-10.

The Todd Declaration establishes that one skilled in the art at the time of the claimed invention would not have been motivated by the disclosure of U'Ren to modify Rolfson to include a germanium source in the Rolfson CVD process because it was generally believed that the presence of germanium resulted in increased surface roughness, larger average grain size, and increased formation of grain boundaries that extend from the surface of the film to the underlying substrate. *See* Todd Declaration at ¶ 8.

Rolfson is directed to a low pressure CVD process in which at least two silicon source gases having different adsorption characteristics (termed "sticking coefficients") are used to grow a polysilicon thin film on a substrate. *See* Todd Declaration at ¶¶ 5, 11. The reason for using two different silicon source gases is to form a polycrystalline film with grain boundaries that are not continuous across the full thickness of the film. *See* Todd Declaration at ¶¶ 5, 11. Thus, the Rolfson CVD process favors the use of silicon sources having sticking coefficients with relatively large differences from one another. *See* Todd Declaration at ¶ 11. Those skilled in the art understood that the relative difference in sticking coefficient between one silicon source and another was effectively **reduced** (contrary to the goals of Rolfson) when the silicon sources were in the presence of a germanium source in a CVD process. *See* Todd Declaration at ¶ 12.

The Todd Declaration establishes that one skilled in the art, at the time of the invention claimed in the above-captioned patent application, would not have been motivated by the disclosure of U'Ren to include a germanium source in the Rolfson CVD process because one skilled in the art would have believed that the presence of the germanium source would reduce the effective difference in sticking coefficients between the silicon sources, thereby reducing the effectiveness of the method employed by Rolfson to achieve discontinuous and randomly oriented grain boundaries. *See* Todd Declaration at ¶ 13.

Rolfson states that the low pressure CVD process can be carried out in a standard low pressure CVD furnace. *See* Todd Declaration at ¶ 16. Rolfson states that the low pressure CVD process can be carried out in a standard low pressure CVD furnace at temperatures of from 580° C to 650° C and at pressures of from about 200 mTorr to 1 Torr. *See* Todd Declaration at ¶ 14.

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Those skilled in the art at the time of the invention claimed in the above-captioned patent application generally recognized that a standard low pressure CVD furnace typically contained numerous wafers. *See* Todd Declaration at ¶ 16. Those skilled in the art were also aware of a generally undesirable phenomenon known as “depletion.” *See* Todd Declaration at ¶ 17. Depletion occurs during CVD processes conducted under mass controlled conditions in which the deposition rate is faster than the rate at which the reactant gas is supplied, resulting in non-uniform deposition across the surface of the substrate and/or between different substrates in a multiple substrate chamber. *See* Todd Declaration at ¶ 17. Depletion effects are exacerbated by the presence of germanium sources, and is a particular problem in standard low pressure CVD furnaces because it results in wafer-to-wafer non-uniformities in film composition and film thickness, thereby leading to different grain structures in each of the films deposited in a given batch of wafers. *See* Todd Declaration at ¶¶ 17, 18.

The Todd Declaration establishes that one skilled in the art, at the time of the invention claimed in the above-captioned patent application, would not have been motivated by the disclosure of U’Ren to include a germanium source in the Rolfson CVD process because one skilled in the art would have believed that the use of the germanium source under the U’Ren mass-controlled flow conditions would have produced undesirable depletion effects in the standard low pressure CVD furnace utilized by Rolfson, particularly at the upper end of the 580° to 650° temperature range used by Rolfson. *See* Todd Declaration at ¶ 19.

In summary, the Todd Declaration establishes at least three separate reasons for why one skilled in the art at the time of the claimed invention would not have been motivated by the disclosure of U’Ren to modify Rolfson to include a germanium source in the Rolfson CVD process:

1. Those skilled in the art generally believed that the presence of germanium resulted in increased surface roughness, larger average grain size, and increased formation of grain boundaries that extend from the surface of the film to the underlying substrate, all of which were considered undesirable by Rolfson;
2. Those skilled would have believed that the presence of the germanium source would reduce the effective difference in sticking coefficients between the silicon sources, thereby reducing the effectiveness of the method employed by Rolfson to achieve discontinuous and randomly oriented grain boundaries;

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3. Those skilled in the art would have believed that the use of the germanium source under the U'Ren mass-controlled flow conditions would have produced undesirable depletion effects in the standard low pressure CVD furnace utilized by Rolfson, particularly at the upper end of the 580° to 650° temperature range used by Rolfson.

No Reasonable Expectation of Success

There is no *prima facie* case of obviousness in the absence of a reasonable expectation of success. *See* M.P.E.P. § 2143. "Evidence showing there was no reasonable expectation of success may support a conclusion of nonobviousness." M.P.E.P. § 2143.03.

Applicant respectfully submits that the combination of Rolfson and U'Ren does not provide a sufficient basis for a reasonable expectation of success. Applicant respectfully directs the attention of the Office to the enclosed Todd Declaration, and respectfully invites the Office to refer to the text of the Todd Declaration for the details of the facts and technical reasoning supporting the conclusions summarized below.

As discussed above, one skilled in the art would have believed that the use of the germanium source under the U'Ren mass-controlled flow conditions would have produced undesirable depletion effects in the standard low pressure CVD furnace utilized by Rolfson, particularly at the upper end of the 580° to 650° temperature range used by Rolfson. *See* Todd Declaration at ¶¶ 17, 18. The Todd Declaration establishes that one skilled in the art, at the time of the invention claimed in the above-captioned patent application, would not have had a reasonable expectation that the process of Rolfson could be successfully modified in light of U'Ren because the use of germanium and/or mass controlled deposition conditions would have caused significant depletion problems in the standard low pressure CVD furnaces used by Rolfson. *See* Todd Declaration at ¶ 20.

Rolfson discloses a deposition pressure/temperature combination of about 200 mTorr to 1 Torr and 580° C. to 650° C. *See* Todd Declaration at ¶ 21. U'Ren discloses a deposition pressure/temperature combination of about 100 Torr to about 200 Torr at 650° C or higher, and about 650° C at 200 Torr. *See* Todd Declaration at ¶ 21. At lower pressures (75 Torr), U'Ren indicates that deposition becomes undesirably amorphous, *see* U'Ren at 10:10-25. *See* Todd Declaration at ¶ 21.

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Although the Office has taken the position that Rolfson “describes temperature up to 675 degrees,” the Todd Declaration establishes that when considered as a whole at the time of the invention claimed in the above-captioned patent application, one skilled in the art would not have been motivated by the disclosure of U’Ren to utilize a deposition temperature of 675° C in the Rolfson CVD process because Rolfson associates this temperature with a process that produces an undesired result. *See* Todd Declaration at ¶ 15. Likewise, although the Office has taken the position that RPCVD and LPCVD steps are interchangeable, the Todd Declaration establishes that one skilled in the art would not regard Rolfson’s LPCVD and U’Ren’s RPCVD steps to be interchangeable in the manner described in the Office Action. *See* Todd Declaration at ¶ 23.

The Todd Declaration further establishes that one skilled in the art, at the time of the invention claimed in the above-captioned patent application, would not have had a reasonable expectation that the process of Rolfson could be successfully modified in light of U’Ren because of the significant differences in the deposition pressure/temperature combinations disclosed by the two references. *See* Todd Declaration at ¶ 22. In particular, one skilled in the art would have believed that U’Ren’s goal of achieving more polycrystalline than amorphous growth would be frustrated at the significantly different deposition pressure/temperature combination disclosed in Rolfson, and that Rolfson’s goal of achieving randomly oriented grains by using multiple silicon sources with different sticking coefficients would be frustrated at the significantly different deposition pressure/temperature combination disclosed in U’Ren. *See* Todd Declaration at ¶ 22.

In summary, the Todd Declaration establishes at least two separate reasons for why one skilled in the art at the time of the claimed invention would not have regarded Rolfson and U’Ren as providing a sufficient basis for a reasonable expectation of success:

1. One skilled in the art, at the time of the invention claimed in the above-captioned patent application, would not have had a reasonable expectation that the process of Rolfson could be successfully modified in light of U’Ren because the use of germanium and/or mass controlled deposition conditions would have caused significant depletion problems in the standard low pressure CVD furnaces used by Rolfson.

2. One skilled in the art, at the time of the invention claimed in the above-captioned patent application, would not have had a reasonable expectation that the process of Rolfson could be successfully modified in light of U’Ren because of the significant differences in the deposition pressure/temperature combinations disclosed by the two references.

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Unexpected Results

Applicant respectfully submits that the above-captioned patent application contains significant evidence of unexpected results that have not been properly evaluated by the Office. "Objective evidence or secondary considerations such as unexpected results . . . must be considered in every case in which they are present." M.P.E.P. § 2141 (emphasis added). In this regard, Applicant respectfully directs the attention of the Office to the enclosed Todd Declaration, and respectfully invites the Office to refer to the text of the Todd Declaration for the details of the facts and technical reasoning supporting the conclusions summarized below.

The Todd Declaration notes that the Office has taken the position that Figures 5-10 and paragraphs 0052 to 0058 of the above-captioned patent application do not show unexpected results because "firstly the unexpected results are not set out and cannot be properly responded to, secondly the results described in the specification are the results that flow logically from the teachings of the prior art." *See* Todd Declaration at ¶ 24. Dr. Todd disagrees with the position taken by the Office for several reasons. *See* Todd Declaration at ¶ 24.

The Todd Declaration explains how the above-captioned patent application at paragraphs 0053 to 0055 shows that the amount of germanium incorporated into a film by a conventional SiGe deposition process is not a linear function of the amount of germane in the deposition gas. *See* Todd Declaration at ¶ 25. The non-linear behavior of the conventional process is observed at various temperatures and thus at various deposition rates, greatly complicating the task of depositing a smoothly graded SiGe film having a specified thickness and a specified Ge content because of the additional difficulties associated with simultaneously compensating for the non-linearities in both Ge concentration and film deposition rate. *See* paragraph 0054 and Todd Declaration at ¶ 25. The substantial non-linearity of Ge incorporation over a broad range of Ge concentrations is recognized as a long-standing problem in the art. *See* Todd Declaration at ¶ 26.

The Todd Declaration explains how the above-captioned patent application at paragraph 0056 shows the unexpected effect of changing the amount of Ge precursor during CVD deposition using a trisilane-containing gas. *See* Todd Declaration at ¶ 27. The use of a deposition gas that contains trisilane greatly simplifies the task of depositing a graded Si-containing film using thermal CVD because such use of trisilane facilitates substantial linearity of Ge incorporation and deposition rate. *See* Todd Declaration at ¶ 28. The Todd Declaration

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establishes that the effect of trisilane on germanium incorporation and flow rate is highly unexpected in view of the long-standing art-recognized problem of non-linear Ge incorporation when using germane with traditional silicon precursors such as silane. *See* Todd Declaration at ¶ 28. The Todd Declaration also explains how the above-captioned patent application at paragraphs 0057 to 0058 enables the use of trisilane to provide additional unexpected results such as higher deposition rates, higher degrees of film uniformity, and smoother surfaces. *See* Todd Declaration at ¶ 29.

In view of the substantial evidence of nonobviousness set forth in the Todd Declaration and summarized above, Applicant respectfully requests reconsideration and withdrawal of the rejection of Claims 1-15 and 20-33 under 35 U.S.C. § 103(a) as being unpatentable over Rolfson in view of U'Ren.

Conclusion

In view of the Amendment to the Claims and Remarks set forth above, Applicant respectfully submits that this application is in condition for allowance, early notification of which would be appreciated. Applicant respectfully invites the Office to contact the undersigned at the telephone number provided below with any questions regarding this application.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

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